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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 133.

B. T. GALLOWAY, *Chief of Bureau.*

PEACH, APRICOT, AND PRUNE KERNELS AS BY-PRODUCTS OF THE FRUIT INDUSTRY OF THE UNITED STATES.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., June 18, 1908.

Sir: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 133 of the series of this Bureau, the accompanying manuscript, entitled "Peach, Apricot, and Prune Kernels as By-Products of the Fruit Industry of the United States."

This paper was prepared by Mr. Frank Rabak, Expert in Drug-Plant Investigations, working under the direction of Dr. Rodney H. True, Physiologist in Charge, who submits this manuscript with a view to publication.

There has been some demand for information along this line from fruit growers, who have recently felt the desirability of working up all products capable of being made a source of profit. In view of the fact that the oils obtained from these kernels are practically identical with those now imported from foreign sources, a fact which is shown in the accompanying bulletin, it seems clear that the information here submitted will meet with a welcome not only from the fruit men but also from the importers of the products concerned.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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PEACH, APRICOT AND PRUNE KERNELS AS BY-PRODUCTS OF THE FRUIT INDUSTRY OF THE UNITED STATES.

BOTANICAL INTRODUCTION.

The natural order Drupaceæ supplies a large number of edible fruits, many of which are grown and marketed commercially on a large scale. Among these the peach, the apricot, and the prune are important.

The apricot is a native of Turkestan and China, though deriving its species name, *Amygdalus armeniaca* L. (*Armeniaca vulgaris* Lam., *Prunus oleoginosa* Desf.), from Armenia, formerly considered its native country. In the United States it is grown for the most part west of the Rocky Mountains.

The peach is also of foreign introduction and is known botanically as *Amygdalus persica* L. (*Persica vulgaris* Mill., *Prunus persica* Benth. and Hook., *Malum persicum* Plinius).

The origin of the peach has been traced to China, though most of the varieties grown in Europe and America prior to the last half century were derived from Persian stock. It is very widely distributed in the United States, being largely grown in California, Colorado, Michigan, Georgia, Missouri, Arkansas, Texas, Delaware, Maryland, West Virginia, New Jersey, and other States.

Of the half dozen species of plums that are commercially grown in the United States the common prune of the market is most important. Though widely distributed, the prune is most largely grown in California, Oregon, Washington, and Idaho, and represents fruit of a few varieties of *Prunus domestica* L.

Near relatives to the species just described are those which bear the sweet and bitter almonds of commerce. The sweet almond is the seed of *Amygdalus communis dulcis* DC., while the bitter almond is designated as *Amygdalus communis amara* DC.

The almond is a native of Africa and the East, but now grows wild in all parts of southern Europe. It has been introduced into California, where the climate seems peculiarly adapted to its growth. While the tree thrives in most of the peach districts, its early-blossoming habit renders it susceptible to injury by spring frosts.

The principal articles of commerce from the almond tree are the kernels from the fruit, both the bitter and the sweet varieties being imported in large quantities from France, Spain, Italy, and the Levant.

The principal products of the genus Prunus are the fruits, which form a very important article of commerce in the United States, as well as in foreign countries. The fruits of the peach, prune, and apricot are produced in large quantities in different portions of the United States, the peach being more generally grown than the apricot and prune, both of which are most largely planted on the Pacific slope, and especially in California.

The production of the three fruits mentioned has assumed considerable proportions within recent years, as is in a measure indicated by the total exportation of these commodities. During the year 1906 there were exported from the United States for foreign consumption 13,760,281 pounds of apricots, with a total valuation of $1,325,422; peaches, 1,181,649 pounds, with a valuation of $110,407; and prunes, 24,869,744 pounds, with a valuation of $1,410,636.[a] These statistics cover simply the dried fruit, no data as to the fresh and canned products being available.

In the course of preparation for the market and before exportation, the apricots and peaches undergo the process of pitting, by means of which the pits or stones are removed from the fruits, while the pitting of dried prunes has been only recently undertaken in a commercial way.

The kernels of the sweet and bitter almonds form, as already stated, important commercial articles. The kernels of both were formerly used in the manufacture of the fixed oil of almonds. In late years the sweet almond has been almost entirely supplanted by the bitter form because of the much lower price of the latter. Both sweet and bitter almonds are also used extensively by confectioners. The fixed oil expressed from bitter almonds is practically identical in composition with that from sweet almonds; and, furthermore, since the press cake from the bitter almond forms a basis for the preparation of the essential oil of almonds, it is used in preference to that of the sweet almond. Both the fixed and volatile oils of almonds are important pharmaceutical articles, the fixed oil being used very largely in the manufacture of emulsions, soaps, ointments, etc., while the bitter almond oil is prized therapeutically largely on account of its sedative action and because it is a suitable and convenient means for the introduction of the very poisonous hydrocyanic acid into remedial agents.

[a] Commerce and Navigation of the United States, 1906, pp. 596–597.

The pitting process, which is applied to the fruits of peaches, apricots, and prunes, yields great quantities of pits or stones. The uses to which these pits have been put heretofore place them in the category of waste products or, in some cases, by-products. Apart from their use as a fuel, the majority have been discarded, with the exception that a certain quantity of apricot pits have been marketed and some peach pits have been sold to nurserymen.

In view of the extensive use of almond kernels in commerce and considering the exceedingly close botanical relation of the peach, apricot, and prune seeds to those of the almond as well as the similarity of composition, there is seemingly no definite reason why the kernels of these three fruits should not demand attention with reference to their possible commercial value.

The purpose of the investigation reported upon in these pages has been to bring about not only a clearer understanding of these kernels with special reference to their likeness to almond kernels, but also to compare chemically the commercial products obtainable from the kernels.

Owing to the very close relationship existing between the kernels of these various fruits and since the commercial products capable of separation from these kernels are of sufficient importance, a new commercial resource suggests itself in the utilization of these waste pits and kernels.

THE RELATION OF PEACH, APRICOT, AND PRUNE KERNELS TO SWEET AND BITTER ALMONDS.

PHYSICAL RELATIONSHIP.

In physical appearance the close similarity between the kernels of the peach, apricot, and prune and those of the sweet and bitter almonds stands out very prominently. They are produced by plants belonging to the same family, the Drupaceæ, and in fact by plants belonging to very closely related genera. All produce a fruit drupaceous in character, with a fleshy pericarp or sarcocarp surrounding the pit. The character of the fleshy portion of the fruit, as well as the external appearance, differs materially, as does also the external appearance of the pit, but the kernels within the pit have the close resemblance that the trees bear to each other, differing chiefly in size.

CHEMICAL RELATIONSHIP.

Chemically the kernels of the peach, apricot, and prune bear, even to a much greater degree than in physical appearance, a close similarity to the sweet and bitter almonds, and especially to the latter.

The composition of bitter almonds is approximately as follows:[a] Fixed oil, 46 per cent; mucilage, 3 per cent; sugar (mostly dextrose), 6 per cent; proteids (including emulsin), 24 to 30 per cent; amygdalin, 1 to 3 per cent; and about 3 to 5 per cent of ash. It is well known that bitter almonds can be made to yield prussic acid (hydrocyanic acid) by simple maceration of the crushed seeds in water. It was formerly supposed that the hydrocyanic acid was contained in the seeds, but Robiquet and Boutron-Charlard[b] in 1830 discovered that this principle does not preexist in the seed of the almond and is not formed until water is present. These investigators discovered a crystalline substance in the almond which was termed amygdalin and which belongs to a class of plant constituents known as glucosides. Glucosides have the property when decomposed or hydrolysed by a ferment or dilute acid or alkali to yield dextrose (or an allied sugar which is constant) and some other compound which is not constant, but which possesses a definite composition. It may therefore be stated that when the two important constituents of the bitter almond, the glucoside amygdalin and the ferment emulsin, are made to interact by the addition of water, the following compounds result as products of the hydrolysis: Dextrose, hydrocyanic acid, and benzaldehyde. The reaction is as follows:

$$\underset{\text{amygdalin}}{C_{20}H_{27}NO_{11}}+2H_2O=\underset{\text{hydrocyanic acid}}{HCn}+\underset{\text{benzaldehyde}}{C_6H_5CHO}+\underset{\text{dextrose}}{2C_6H_{12}O_6}.$$

The emulsin, as will be observed, takes no quantitative part in the reaction, but in the presence of water simply acts as a catalytic agent, causing the decomposition of the amygdalin, as shown in the above reaction.

The hydrocyanic acid and benzaldehyde comprise what is known in commerce as the volatile oil of bitter almonds. It is therefore evident that the chief constituents of bitter almonds are the fixed oil, the amygdalin, and the proteids, including emulsin.

The composition of the kernels in question—those of the peach, apricot, and prune—is practically the same as that of bitter almonds, only a slight variation existing. The percentages of fixed oil and amygdalin (which is an important constituent for the production of volatile oil) in the seeds compare very favorably with the quantities of the same constituents found in a commercial sample of bitter almonds. These comparative results are shown under the discussions of the fixed and volatile oils. No doubt remains, therefore, that commercial products similar to those produced from the bitter-almond kernels may be produced from the kernels of the peach, apricot, and prune.

[a] National Dispensatory, 1905, p. 163.

[b] Annales de Chimie; Jour. of Pharm., 1833, p. 67.

COMMERCIAL PRODUCTS FROM KERNELS OF THE PEACH, APRICOT, PRUNE, AND ALMOND.

By proper manipulation of the kernels from the peach, apricot, prune, and almond, there may be produced (1) the fixed oil and (2) the volatile oil.

The fixed oil obtained by expression of the sweet and bitter almond kernels constitutes a very important article of commerce. Owing to the consistent high prices of the crude material, however, the fixed oil has ceased in a large measure to be prepared from the almond kernel, which has been replaced by cheaper materials, such as apricot and peach kernels.

As early as 1888[a] a fixed oil was expressed commercially from peach and apricot kernels. It was also extracted on a large scale in the temperate belt of Asia, between east Hindustan and Persia, from apricot and peach seeds.[b] Owing to the rapid displacement of almond oil by oils made from other kernels, much attention was given to the growth and production of apricots and peaches in European and Asiatic countries, growers in the vicinity of Damascus and Syria being especially active in the production. From the former locality there were exported in 1889[c] as much as 575,000 kilos of kernels, and from Syria in 1895[d] about 300,000 kilos, mostly to Europe, where the fatty oil was expressed. Schimmel & Co.[e] reported in 1889 that the fixed oil of almonds was generally represented on the market by peach-kernel oil. The substitution of peach-kernel oil for the true almond oil has been greatly minimized by the enforcement of the Federal and State food laws.

The production of fixed oils had up to this time (1889) been confined entirely to foreign-grown apricot and peach kernels. A shortage of crops or possibly a greater demand introduced a new factor into the situation. The California production was unusually large, and the kernels had found no market and were considered as useless by-products. The coincident shortage in Europe caused considerable consignments of the apricot kernels to be shipped from the United States,[d] principally from California; and, since peaches are also grown in enormous quantities, the kernels from the peach pits gradually entered the same channels, and in 1900[f] about 40,000 kilos were exported to Europe.

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[a] Ber., Schimmel & Co., April, 1888, p. 26.

[b] Maben, Thomas. Pharm. Jour. & Trans., vol. 16, p. 797. 1886.

[c] Pharm. Jour. & Trans., vol. 20, p. 856. 1889–90.

[d] Rept., Schimmel & Co., April, 1897, p. 5.

[e] Ber., Schimmel & Co., October, 1889. p. 34.

[f] Rept., Schimmel & Co., April, 1900, p. 4.

Owing to the vast inroads made by these products upon the production of almond oil, an oil for the market was produced either from apricot or peach kernels, depending upon the relative market value of each, apricots being as a rule cheaper. The oil almost without exception was produced from apricots.[a]

Later, oil of sweet almonds became almost a rarity, being prepared only to a small extent from bitter almonds. It was asserted that for every pound of this oil imported at least 100 pounds of peach or apricot kernel oil were also imported.[b]

The adulteration of oil of almonds with apricot-kernel oil is mentioned as early as 1866,[c] and now the adulteration has been transformed into almost a total replacement[d] of the true oil by the oil from these kernels.

The volatile oil of bitter almonds was reported as being manufactured from seeds of the apricot imported into France from Asia Minor in 1877.[e] Somewhat later it was declared that the chief raw materials[f] for the manufacture of bitter-almond oil were peach and apricot kernels, this statement being reconfirmed in 1901[g] by the assertion that bitter-almond oil from bitter almonds was rarely met with in commerce, but was represented by the volatile oils from apricot and peach kernels, there being not the slightest difference between the oils.

In 1903 and 1904[h] the principal raw material was Syrian apricot kernels, which could be purchased very favorably; nevertheless, the demand exceeded the output, and the California kernels were again drawn upon.

Inasmuch as both fixed and volatile oils can be prepared and are prepared from peach and apricot kernels, and, furthermore, since the demand at most times seems to equal and in some cases exceed the supply, the question of the manufacture of these commodities in the United States, where so much raw material is available, presents itself as one of importance.

It has been pointed out that the present commercial supply of these oils is derived from European countries, where the products are manufactured principally from kernels of foreign production, but to some extent from kernels produced in America. The enormous output of fruits from the peach, apricot, and prune orchards in the United States has been alluded to in the foregoing pages; also the fact that

[a] Umney, J. C., and Swinton, R. S. Brit. Pharm. Conf., 1899, p. 444.
[b] Pancoast, G. R., and Kebler, L. F. Amer. Jour. Pharm., vol. 74, p. 495. 1902.
[c] Nickles, M. J. Chem. Centralbl., 1866, p. 557; Jour. de Pharm., 1866, p. 332.
[d] United States Dispensatory, 19th ed., p. 832.
[e] Amer. Jour. Pharm., vol. 49, p. 421. 1877.
[f] Ber., Schimmel & Co., October, 1889, p. 34.
[g] Rept., Schimmel & Co., April–May, 1901, p. 9.
[h] Rept., Schimmel & Co., April–May, 1904, p. 7.

in conjunction with this large production of fruit there are produced immense quantities of the kernels which form the chief raw material for the manufacture of the fixed and volatile oils of almonds.

Neither fixed nor volatile oils are produced in the United States from these kernels to any extent, the consumers depending almost entirely upon foreign production.

Since the oils from the kernels of the peach, apricot, and prune are closely related and allied to the corresponding oils from the sweet and bitter almonds, the following work was undertaken with a view to studying the oils and their properties. It must not be inferred that the object is to encourage adulteration or substitution, but the similarities and dissimilarities which exist between the oils from these kernels and those from kernels of almonds will be shown. Conclusions may then be deduced concerning the real merits of each individual oil.

THE FIXED OIL.

METHODS OF EXTRACTION.

Two methods are at the present time in use for the extraction of fixed oils on both a large and a small scale. Extraction by pressure is possibly made use of more extensively than any other method. For this purpose hydraulic presses are usually employed, consisting essentially of a pump for furnishing the necessary pressure and a pressing box to which the pressure is imparted and in which is placed the material to be pressed. Usually, in pressing seeds such as those of the peach, apricot, or prune, a press so constructed as to allow of warming the pressing plates is employed, thus insuring a more thorough expression of the oil and consequently a higher yield. Judgment must, however, be exercised in order to prevent a deterioration in the quality of the oil, which is very likely to occur if excessive heat is applied.

For more detailed information on hydraulic presses and their application, reference may be made to such works as Schaedler, Die Technologie der Fette und Oele des Pflanzen- und Thierreichs; Lewkowitsch, Chemical Technology and Analysis of Oils, Fats, and Waxes, 2 volumes; and Hefter, Die Technologie der Fette und Oele.

The method of extraction with organic solvents is also employed commercially, large extractors of various construction being used for the purpose. The media used for extraction comprise a certain class of organic compounds which have the property of dissolving fats and oils. Among them may be mentioned carbon disulphid, ether, chloroform, benzine and petroleum ether. Each solvent possesses its characteristic advantage and also disadvantages. Some may be recommended for their comparative cheapness and others on account

of their less inflammable nature and better extracting powers. Any of the solvents used for extraction purposes may be recovered by proper means and again utilized for the same purpose, the expense being thereby reduced to the minimum.

The form of apparatus varies somewhat for each individual solvent. Generally, however, extractors are constructed of suitable metal, preferably copper, and consist essentially of the extractor, the condenser, and the receiving vessel. The theoretical underlying principle is that of continuous extraction, heat being applied preferably in the form of steam (thus reducing danger from inflammability) to the receiving vessel containing the solvent, thus vaporizing the solvent, which in turn is condensed by a proper condensing device placed in such a position that the condensed solvent percolates through the material, carrying with it in solution the fixed oil. The solution of the fixed oil flows into the receiver, where the solvent is again vaporized and condensed, thus completing the cycle. Heat is constantly applied, so that the process becomes a continuous one. More detailed information may be derived from the references already cited.

An accurate estimate of the expense required for the installment of either hydraulic presses or an extraction apparatus can not be given, the price varying naturally with the size of the plant and the output desired. It may be stated, however, that such apparatus once installed has an indefinite period of usefulness with only the expense of operation.

EXTRACTION OF THE FIXED OILS AND LABORATORY DATA OF PHYSICAL PROPERTIES.

In order to confirm some of the earlier statements concerning the fixed oils obtained from such seeds as those of the peach, apricot, prune, and almond, and for the sake of comparison both physically and chemically, a series of laboratory experiments was carried out on several samples of such kernels obtained from different sources.

Peach, apricot, and prune kernels were obtained from various California packing houses, and sweet and bitter almonds were purchased on the market as United States Pharmacopœia articles. The genuineness of the California kernels can not be doubted; belief in the genuineness of the sweet and bitter almonds purchased on the open market rests on the statement of the supplying firm that they were imported seeds coming from Valencia, Spain, and from Italy, respectively.

Sufficient quantities of peach, apricot, prune, and sweet and bitter almond kernels were subjected to extraction with ether in a Soxhlet extraction apparatus, which in principle is identical with the large continuous extractors used commercially.

The percentage yield of fixed oils after complete evaporation of the solvent in each case, together with the other physical properties, is shown in Table I. For purposes of comparison the results obtained by a foreign investigator in the case of peach, apricot, and prune kernels are included.

TABLE I.—*Character and yield of fixed oils obtained from various fruit kernels.*

Sample.	Yield of oil.	Specific gravity.	Color.	Odor.
	Per cent.			
Peach kernels (California)	39.5	[a] 0.9166	Yellow	Fatty nearly odorless.
Apricot kernels (California)	40	[a] 0.9168	Straw-colored	Slightly fatty, nearly odorless.
Prune kernels (California)	35	[a] 0.9164	Golden yellow	Fatty, with nut-like odor.
Sweet almonds (Valencia, Spain)	49	[a] 0.9162	Light yellow	Nearly odorless, fatty.
Bitter almonds (Italy)	42.3	[a] 0.9158	Yellow	do
Sweet almonds (oil purchased on market).		[a] 0.9160	do	do
Apricot kernels (foreign) [b]	40 to 45	[c] 0.915	Nearly colorless, becoming yellow.	Resembles oil of almonds.
Peach kernels (foreign) [b]	30	[d] 0.916	Clear and yellow	do
Prune kernels (foreign) [b]	25 to 30	[c] 0.9127	do	Agreeable; almond-like.

Sample.	Taste.	Congealing point.	Soluble in—
Peach kernels (California)	Bland, fatty, nut-like.	Clear, but viscid at −16° C.	Ether, chloroform, benzine; partly in alcohol.
Apricot kernels (California)	Fatty and nutty	do	Do.
Prune kernels (California)	Bland, fatty, nutty, slightly sweet.	do	Do.
Sweet almonds (Valencia, Spain)	Nut-like and fatty	do	Do.
Bitter almonds (Italy)	Bland and fatty	do	Do.
Sweet almonds (oil purchased on market).	do	do	Do.
Apricot kernels (foreign) [b]	Mild and agreeable	Clear, but viscid at −14° C.	
Peach kernels (foreign) [b]	Resembles oil of almonds.	Clear, but viscid at −18° C.	
Prune kernels (foreign) [b]	Agreeable; almond-like.	Viscid at +4° C.; congeals at −8.75° C.	

[a] At 25° C.
[b] According to Schaedler, Die Technologie der Fette und Oele des Pflanzen- und Thierreichs, pp 537–539.
[c] At 15° C.
[d] At 20° C.

The percentage yields of oils in the several cases, although varying to a certain extent, are amply sufficient to warrant extraction commercially. Sweet and bitter almonds contain a slightly higher percentage of fixed oil, which is especially noticeable in the case of sweet almonds.

The specific gravities of the oils examined are practically identical, the greatest difference being but 0.001, which is within the limit of experimental error. As a rule the specific gravities of oils bear some relationship to their composition.

The color, odor, and taste, as well as the congealing temperature and solubility, reveal no broad differences. The congealing point, being a factor which might be materially influenced by any great differences in composition, is especially useful in the detection of adulterations with oils of an entirely distinct type. None of the oils congealed at −16° C., remaining clear and viscid, the observations differing on this score from those made abroad.

Considering all points of similarity and dissimilarity in the physical properties of the fixed oils from these kernels, any line of demarcation which might be drawn seems rather obscure, the physical properties of the almond oils being so minutely varied as not to indicate any radical variation in composition.

CHEMICAL EXAMINATION.

With a view to making a chemical comparison of the oils, several of the more important so-called chemical constants were determined for each of the oils of peach, apricot, prune, and sweet and bitter almond kernels. For purposes of better illustration, these chemical constants are presented in Table II, thus facilitating a ready means of discrimination between the individual members.

TABLE II.—*Chemical constants in oils obtained from various fruit kernels.*

Source of oil.	Free fatty acids.		Saponification number (Koetts-toerfer number).	Iodin absorption (Hubl's number).
	Acid number.	Calculated as oleic acid.		
		Per cent.		
Peach kernels (California)	0.83	0.418	187	110
Apricot kernels (California)	0.75	0.38	203	107
Apricot kernels (same as above, 1 year old)	13.3	6.68	180	118
Prune kernels (California)	1.9	0.955	160	105
Sweet almonds (Valencia, Spain)	0.61	0.32	170	106.8
Bitter almonds (Italy)	1.7	0.86	188	106.3
Sweet almonds (purchased on market)	3.5	1.76	193	107.3

FREE FATTY ACIDS.

The free fatty acids of an oil, although not an indication of its value, are nevertheless an index of age or rancidity and hence become a partial factor in the qualitative valuation of a fixed oil.

Almost without exception, unless the strictest precautions are observed to protect an oil from light and air, the free fatty acids increase with the age of the oil. Even an oil kept in partially filled bottles or containers will be acted upon by the oxygen of the air inclosed, with the aid of light, producing a liberation of free acid; or, in other words, the glycerin esters of fatty acids suffer decomposition with the liberation of the free acid and glycerin.

The free fatty acids were determined by neutralizing carefully a weighed quantity of the oil mixed with alcohol with N/10 potassium hydroxid V. S. and noting the number of cubic centimeters of the alkali consumed, using phenolphthalein as an indicator.

The number of milligrams of potassium hydroxid consumed by one gram of the fixed oil represents the acid number of the oil. From the amount of potassium hydroxid consumed the percentage of oleic acid which that amount represents was calculated from the oleic acid factor (1 c. c. N/10 KOH = .0280 gm. oleic acid).

By reference to Table II the fact that all fresh oils possess but little acidity is clearly evident, as the fresh oils from peach, apricot, and prune kernels and the sweet and bitter almond oils show a minimum of 0.32 per cent and a maximum of 0.955 per cent of free acid calculated as oleic acid. Noteworthy here, also, is the abnormally high acidity of the apricot oil taken after standing for a period of one year in a half-filled bottle and only fairly protected from light, the acidity having been multiplied by 17.5. Attention is also called to the acidity of the sweet almond oil purchased on the market, which possesses about five times the acidity of the freshly extracted oil and which serves in a measure to indicate that the oil was slightly aged.

The percentages of free acid in the oils freshly extracted from peach, apricot, and prune kernels, as may be seen, vary but slightly from those of the oils of either sweet or bitter almonds, which seems to indicate that as far as free acidity is concerned they are comparable to a high degree.

SAPONIFICATION VALUE.

The saponification value of a fatty oil, while not expressing a direct measure of the quality of an oil, does become an important and influential factor in the judgment against other oils and as a basis of comparison of several fatty oils.

The saponification numbers, or Koettstoerfer numbers, were determined according to the method prescribed by the United States Pharmacopœia,[a] which consists in heating on a water bath for a half hour a weighed quantity of oil with a measured volume of alcoholic potassium hydroxid and titrating back the excess of alkali by means of half-normal hydrochloric acid. In this manner the amount of potassium hydroxid decomposed by reaction is readily calculated. The saponification number represents the number of milligrams of potassium hydroxid required to saponify completely the fatty acid esters or glycerids in one gram of oil.

[a] United States Pharmacopœia, eighth revision, p. 535.

Peach, apricot, and prune kernel oils compare, as may be seen, more or less favorably with the oils from sweet and bitter almonds in saponification values. The oil from prune kernels shows a value somewhat lower than the several other oils, the sweet almond oil being most nearly associated with it, while, on the other hand, peach kernel and bitter almond oil are practically identical in saponification values. The oil of apricots is slightly above and in fairly close relationship to the sweet almond oil purchased on the market.

The United States Pharmacopœia[a] requires for the expressed oil of almonds a saponification equivalent of 191 to 200, the oil of the market examined being the only oil besides the apricot falling within the requirement, the remaining oils being below the requirement.

Although no preference can be given to an oil on account of the saponification equivalent, it tends to show that the composition of the oils are related at least in the percentage of saponifiable glycerin salts of fatty acids.

IODIN ABSORPTION.

Of somewhat greater significance is the power of a fatty oil to absorb iodin, usually termed iodin absorption or iodin number. The iodin number represents the percentage of iodin absorbed by a fatty oil under certain conditions. The iodin value is dependent upon the amount of unsaturated fatty acids in the oils. The most common unsaturated acid occurring in animal or vegetable oils is oleic acid, which is present in the oil only to a small extent as the free acid, but generally as the glycerid olein. These unsaturated fatty acids or glycerids combine directly with iodin or bromin, and upon this property is based the method employed so extensively in the quantitative examination of fixed oils. The iodin number is therefore a measure of the unsaturated acids present in a fixed oil.

The iodin absorption power was determined according to the United States Pharmacopœia,[b] the principle of the method depending upon the absorption of iodin by the oil, the amount taken up being determined by titration of the excess by means of N/10 sodium thiosulphate V. S.

The iodin values of the various oils indicate a close relationship to the almond oils. The oil from apricot and prune kernels and the three almond oils are very similar, whereas the peach oil indicates only a slightly higher percentage of unsaturated fatty acids.

It is of interest to note at this point that the apricot oil after being aged for one year shows an increase in iodin number, indicating that the amount of unsaturated acids has increased while the saponification value has decreased, owing possibly to the liberation of a considerable amount of free acids.

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[a] United States Pharmacopœia, eighth revision, p. 307.

[b] United States Pharmacopœia, eighth revision, p. 527.

REACTIONS TOWARD REAGENTS.

Of lesser importance in the judging of some fixed oils is their behavior toward reagents. One of the principal tests recommended by the United States Pharmacopœia for distinguishing oil of almonds from peach and apricot kernel oils is what is known as the elaidin test,[a] which depends on the reaction of nitric acid upon the olein of the oil, forming a polymerized, yellow, viscous compound, *elaidin*.

Inasmuch as fixed oils are known to give characteristic color reactions with certain reagents, a comparison of the colors produced with a few reagents was made, as shown in Table III. It is of course to be borne in mind that color reactions are no absolute index of the quality of a fatty oil, but serve only as a means of comparison.

TABLE III.—*Color reactions with certain reagents upon fixed oils obtained from various fruit kernels.*

Source of oil.	Nitric acid.	Nitric acid fuming.	Sulphuric acid.	Sulphuric acid + nitric acid.	Elaidin test.
Peach kernels (California).	Pink.....	Yellowish red.	Dirty gray to green.	Brown.....	Grayish green. Yellow green mass after standing.
Apricot kernels (California).	Reddish....	Reddish....	Yellowish to brownish red.	Dark brown	Grayish green. Pulpy yellowish brown mass after standing.
Prune kernels (California).	Light reddish.	.....do.....	Yellowish to reddish.	Red brown.	Gray green. Light brown green mass after standing.
Sweet almonds (Valencia, Spain).	Pink.....	Yellowish red.	Dirty green...	Deep red brown.	Bluish green. Yellow green and solid after standing.
Bitter almonds (Italy).	.....do.....	.....do.....	.....do.....	Brown.....	Bluish green mass. Yellow green and soli l after standing.
Sweet almonds (purchased on the market) [a]	Faint pink..	.....do.....	.....do.....	Deep red brown.	Bluish green. Olive green mass after standing.

[a] Purchased as United States Pharmacopœia almond oil.

The color reactions, as shown by the above tabulation, reveal some differences in the oils, although in most cases they are rather trifling. The elaidin test, on the other hand, instead of disclosing characteristic differences shows to a great extent similarities in the oils. As has been previously stated, the color reactions form no basis of declaring any superiority but illustrate rather forcibly the kinship existing in the oils under consideration.

COMPARISON WITH ALLIED FIXED OILS.

While it is impossible to assert from a careful scrutiny of the above data that the oils of peach, apricot, and prune kernels are in every way equal to those obtained from almonds, it is reasonably safe to state that the oils are not radically different from them. The botanical and physical similarities of the trees and their products are substantially upheld by the exceedingly close similarity from a chemical

[a] United States Pharmacopœia, eighth revision, p. 307.

viewpoint. The differences observed are, however, not sufficiently marked to justify a statement of superiority of one over the other.

In all cases the range of differences is comparatively small and only in the prune-kernel oil are the chemical constants at all noticeably dissimilar. The fact that the prune-kernel oil behaves slightly unlike the other members can no doubt be accounted for from the fact that, according to the statements of the suppliers of these kernels, the prunes are subjected to heat during the process of pitting or before. This is necessary because of the difficulty which is experienced in separating the fleshy sarcocarp from the pits. The application of this heat, even if not excessive, would be injurious in its action on the fixed oil in the seeds.

The relationships, both physical and chemical, between the fixed oils from apricot, peach, and prune kernels and the oils of almonds, bitter and sweet, are of the closest, and in several instances the oils practically coincide with each other. Just where a dividing line could be drawn is rather obscure. It therefore seems entirely reasonable, in view of these likenesses, to use these fixed oils in the same manner as the oils obtained from the sweet and the bitter almond.

COMMERCIAL VALUE.

In commerce the oils of almond kernels and also the oils of peach and apricot kernels are used extensively both in the arts and in medicine, and in fact are often employed interchangeably.

Medicinally or pharmaceutically the oils are useful in the preparation of ointments, liniments, emulsions, and other preparations; also as vehicles for the administration of other medicinal agents. McWalter[a] states that therapeutically or pharmacologically there is no distinction between the oils from peach and apricot kernels and the almond oils. Therapeutical differences, however, do exist between the almond, peach, and apricot kernel oils on the one hand and the oils from an entirely distinct source, such as rape, sesame, etc., on the other. Almond, peach, and apricot oils are sweet, nonacrid, nonacid, and yet easily saponifiable and emulsifiable, and are therefore especially suited to certain uses.

The oil of prune kernels has never reached the market owing to its undeveloped production; but there seems no reason why, as a close relative to the almond, peach, and apricot oils, its use should not become commercial also, provided the pitting of prunes becomes general, with a consequent ample supply of pits.

It may also be remembered that owing to the adulterations with unrelated oils to which almond oils are subjected because of their

[a] McWalter, J. C. Pharm. Jour., vol. 74, p. 181. 1905.

high prices, their activity and use are unquestionably hampered. The almond oils, although no doubt still adulterated with peach and apricot kernel oils, have been in a measure entirely replaced by the substitution of these oils. When adulterated with or replaced by peach and apricot oils, their use and action are not so seriously affected, but when adulterated with such oils as rape, cotton, sesame, poppy, olive, and arachis,[a] of entirely different composition, it is almost certain that contrary action and effects must be produced.

Important uses of the oils lie possibly in their great value in the preparation of toilet soaps and cosmetics. Experiments have been made in utilizing the fixed oils [b] (expressed from peach and apricot kernels) in the preparation of high-grade soaps with very satisfactory results, complete saponification, formerly a disputed point, being obtained. Hobein [c] states that almond oil makes excellent toilet soaps, which impart a most agreeable action to the skin. Schimmel & Co.[d] state that owing to the low prices at which peach-kernel oil can be offered, it has attracted much attention in the toilet-soap industry.

The present wholesale prices [e] of oil of sweet almonds (true) is from 45 to 55 cents a pound, while peach-kernel oil is listed at from 28 to 36 cents a pound. Apricot and prune kernel oils are not on the lists, the latter because it has never been produced commercially as yet, and the former being possibly sold as sweet-almond oil.

Of almond oil designated as sweet-almond oil, the importation[f] during the year ended June 30, 1906, amounted to 155,661 pounds. No record of the importation of apricot or peach kernel oil is available, but this in all probability aggregates much more than that of almonds, since the almond oil is chiefly consumed in pharmaceutical channels. It may be entirely possible that the above statistics also include some apricot and peach kernel oil.

THE VOLATILE OIL.

Previous statements have been made to the effect that the volatile oil from peach, apricot, and prune kernels does not exist as such in the kernel, but is dependent for its formation upon two important constituents, namely, the glucosid amygdalin and the ferment emulsin. When these two substances are brought to react in the presence of water, the volatile oil (benzaldehyde and hydrocyanic acid) and dextrose are produced. The amount of volatile oil capable of being

[a] Allen, W. E., and Brewis, E. T. Trans. Brit. Pharm. Conf., p. 359. 1900.
[b] Rept., Schimmel & Co., April, 1893, p. 8.
[c] Hobein, M. Pharm. Post, p. 787. 1892.
[d] Rept., Schimmel & Co., October, 1894, p. 6.
[e] Oil, Paint, and Drug Reporter, vol. 73, No. 5, p. 32.
[f] Commerce and Navigation of the United States, p. 288. 1906.

formed is dependent in a measure on the amount of amygdalin present in a given quantity of kernels. It is therefore of interest to compare the relative yields of amygdalin from peach, apricot, and prune kernels with the yield from bitter almonds. Bitter almonds, as previously stated, contain 1 to 3 per cent of amygdalin.[a] By complete extraction of peach kernels with hot absolute alcohol a yield of 3 per cent of crystalline amygdalin was obtained; of apricot kernels, 2 per cent, and of prune kernels, 1.5 per cent. The amount of emulsin present does not affect directly the yield of volatile oil, inasmuch as it requires but one part of emulsin to hydrolyse about twelve parts of amygdalin.

As early as 1875 [b] bitter-almond oil was known to have been manufactured from peach kernels. At the present time the principal raw materials which serve for the manufacture of this oil are peach and apricot kernels,[c] and it is further stated that the article suffers very much from the scarcity of raw material during some seasons.[d]

The distillation of the oil from bitter almonds has fallen off greatly, and in fact has been practically discontinued, the oil being at present derived from apricot and peach kernels. This assumption is substantiated since the United States Pharmacopœia,[e] the National Dispensatory,[f] and the United States Dispensatory[g] describe the oil as "the volatile oil distilled from bitter almonds and other seeds containing amygdalin," the peach and apricot kernels falling in the category of "other seeds containing amygdalin."

METHODS OF EXTRACTION AND YIELD OF VOLATILE OIL FROM THE PRESS CAKE.

The extraction of the volatile oil from the press cake which remains after expressing the fixed oil from the seeds depends upon a process of maceration and subsequent distillation. The proper maceration of the press cake with water is an important essential for acquiring a maximum yield of oil, since the oil is formed by a process of fermentation. Much credence is generally given to the supposition that since emulsin is prone to decomposition at high temperatures the reaction should be completed before distillation is begun. The exact time for the reaction to complete itself has been a subject of some

[a] National Dispensatory, pp. 163–164. 1905.

[b] Proc. Amer. Pharm. Assoc., vol. 23, p. 504. 1875.

[c] Rept., Schimmel & Co., October, 1905, p. 5; National Dispensatory, p. 1054, 1905; Gildemeister, Hoffmann, and Kremers, The Volatile Oils, pp. 437–438.

[d] Rept., Schimmel & Co., October, 1907, p. 11; ibid., April, 1887, p. 20; ibid., April–May, 1906, p. 8.

[e] United States Pharmacopœia, eighth revision, p. 306.

[f] National Dispensatory, p. 1054. 1905.

[g] United States Dispensatory, 19th ed., p. 829.

comment, Pettenkofer[a] stating that forty-eight hours of maceration are required for the greatest yield of oil. Later Pettenkofer proposed a new method of maceration and distillation in which twelve hours[b] was given as the time of maceration.

The question of maceration no doubt is one of prime importance, and accordingly several alterations were applied in the laboratory with a view to determining the most practicable method as well as the one yielding the greatest quantity of oil.

The method promulgated by Pettenkofer as being most productive was applied in each case and consists in substance as follows: Of ground seeds 12 parts are added to from 100 to 120 parts of boiling water, and the mixture is kept at this temperature for fifteen to thirty minutes and then cooled. To the cooled mixture 1 part of fresh seeds mixed with 6 to 7 parts of cold water is added and the whole is allowed to macerate for twelve hours. The hot treatment extracts the amygdalin and the addition of fresh seeds supplies sufficient emulsin to hydrolyse the amygdalin. The results are as follows:

TABLE IV.— *Yield of volatile oil obtained from various fruit kernels.*

Quantity and kind of kernels distilled.	Quantity of luke-warm water added.	Period of maceration.	Yield of oil.	Yield from whole seed.	Yield calculated from press cake.	Yield obtained according to Pettenkofer, calculated from press cake.
Grams.	*Cubic centimeters.*	*Hr. min.*	*Grams.*	*Per cent.*	*Per cent.*	*Per cent.*
600 (peach)	2,000	1 30	4.2	0.7	1.17	1.26
1,000 (apricot)	2,000	0 30	16.0	1.6	2.6	1.8
1,000 (apricot)[a]	2,000	0 30	8.0	0.8	1.33	.....
1,000 (prune)	1,500	0 30	3.0	0.3	0.47	.....
650 (prune)	2,000	1 00	3.0	0.46	0.71	0.61
700 (bitter almond)	2,000	1 00	5.7	0.81	1.15	.....

[a] Aqueous distillate cohobated but twice.

The results obtained seem to indicate that the time of maceration bears little relationship to the actual yield of oil, and apparently the reaction is completed in as short a time as a half hour, since the yield of oil obtained by maceration from a half hour to one and one-half hours is in most cases greater than a maceration of twelve hours.

Mention must also be made here of the separation of the oil from the distillate. The oil, being rather soluble in water (1 part in 300 parts), does not permit of a complete separation unless the distillate is subjected to a process of cohobation (i. e., redistillation of the aqueous distillate by direct application of heat, distilling over one-third to one-half of the solution, which in turn is subjected to the

[a] Pettenkofer. Jour. de Pharm. et Chim., 1862, p. 432.
[b] Pettenkofer. Liebig's Annalen, vol. 122, p. 81.

same process). In all of the distillations the results of which are presented in Table IV the aqueous distillate was cohobated four times and the oil separated and weighed. Owing to the ease of error in these distillations and in the separation of such small quantities of oil, the percentages given do not express absolute but only approximate yields. However, the percentages are rather too low than too high, since a distillation on a large scale would correspondingly diminish the experimental error entering into both distillation and separation.

By careful observation of the results of the distillations, the yields of oils appear to be equal to and in some cases considerably greater than the usual yield of oil from bitter almonds. The yield of oil from bitter almonds varies from 0.5 to 0.7 per cent,[a] but according to Whipple[b] a yield of 1.35 per cent was obtained from the ground cake.

The amount of oil obtained from apricot kernels was exceedingly high, 2.6 per cent of oil being obtained after complete cohobation of the distillate. A second distillation of apricot kernels indicated a yield of 1.33 per cent, which was much lower, owing to the fact that cohobation was resorted to but twice in order to ascertain whether the composition of the oil was affected in any way by several cohobations.

Peach kernels yielded 1.17 per cent of volatile oil (calculated from press cake), while prune kernels showed a much lower percentage, 0.71 per cent being obtained. This in part is accounted for by the lower content of amygdalin in the seeds and also by the possible effect of the heat employed during the pitting process upon the emulsin, which is destroyed or rendered less active by heat.

It is self-evident that twelve-hour macerations are not conducive to higher yields of oils, as was generally held. The process was less expeditious and in most cases less productive. The low production of oil by long maceration may be explained by the possible oxidation to benzoic acid of the benzaldehyde which is formed in the reaction and which constitutes the major part of the oil.

The most expeditious as well as the most productive method for securing volatile oil from these kernels, to be recommended because of its simplicity and ease of operation, is as follows: One part of ground kernels (or press cake) is mixed with 2 to 3 parts of lukewarm water and allowed to macerate or react with frequent agitation for a period of about one hour, after which steam under slight pressure is passed into the mixture and distillation is conducted until approximately four parts of distillate are obtained. After separation of the nonsoluble oil from the distillate, provided a complete yield of oil is desirable,

[a] Gildemeister, Hoffmann, and Kremers. The Volatile Oils, p. 437.

[b] Whipple. Pharm. Jour., vol. 10, p. 297.

the distillate is subjected to the process of cohobation three or four times in order to recover the oil which is in solution.

In this manner an exceedingly high yield of volatile oil is obtained, whereas if the distillate were not redistilled only approximately one-half or two-thirds of the oil would separate from the aqueous solution.

PHYSICAL AND CHEMICAL EXAMINATION.

Inasmuch as it is generally stated that the volatile oils from the peach and apricot are identical in every way with the oil from bitter almonds, the work of examination and comparison was undertaken to test this claim.

Since the United States Pharmacopœia,[a] in which the "oil from bitter almonds and other seeds containing amygdalin" is official, specifies certain physical and chemical properties, the analyses were taken up along these lines.

Chemically considered, the value of the oil is based upon the percentage of benzaldehyde and hydrocyanic acid which it contains.

Parallel to the physical and chemical analyses of the kernel oils, the analyses of bitter-almond oil freshly distilled from the bitter almonds and also of a market sample of the oil were jointly carried on for purposes of comparison. The results are shown in Table V.

TABLE V.—*Analyses of oils obtained from various fruit kernels.*

Number.	Kind of volatile oil.	Color.	Odor.	Taste.	Soluble in—	Specific gravity at 25° C.	HCn. (a)	Benzaldehyde (b)
							P. ct.	P. ct.
1	Peach	Faint straw.	Bitter almond-like: somewhat irritating.	Sweet and pungent.	Alcohol and ether, equal volumes (70 per cent alcohol).	1.068	2.20	73.1
2	Apricot	Light yellow	Aromatic: almond-like.	Sweet; intensely pungent.	do	1.062	2.40	[c] 61.8
3	Do	Straw color.	do	do	do	1.080	2.05	[d] 88.7
4	Prune	Faint straw.	Strong benzaldehyde.	Sweet and pungent.	do	1.050	1.75	76.0
5	Bitter almond	do	Less aromatic; fainter than above oils.	Sweet; less pungent.	do	1.056	4.80	62.0
6	Bitter almond (imported).[e]	Golden yellow.	Not agreeable; strongly almond-like.	Sweet; very pungent and biting.	do	1.057	2.80	63.9

[a] Assayed for hydrocyanic acid by the volumetric method (United States Pharmacopœia, eighth revision, p. 306).
[b] Assayed for benzaldehyde by the sodium sulphite volumetric method (United States Pharmacopœia, eighth revision, p. 306).
[c] Assayed after standing six weeks.
[d] Same as No. 2, assayed immediately after distillation.
[e] Purchased as United States Pharmacopœia bitter-almond oil.

The physical properties of the kernel oils suggest but very little difference between the sample extracted for experimental purposes and the sample of bitter-almond oil purchased on the market. As far

[a] United States Pharmacopœia, eighth revision, p. 306.

as color, odor, taste, and solubility are concerned the oils are practically identical, these properties being, however, of only comparative value. The specific gravities show differences which can hardly be construed to denote radical internal variation. The specific gravities of the peach and apricot oils fall very slightly outside of the limits prescribed by the United States Pharmacopœia, eighth revision, for oil of bitter almonds, but the other properties correspond strikingly.

The pharmacopœial requirement chemically is not less than 2 nor more than 4 per cent of hydrocyanic acid and not less than 85 per cent of benzaldehyde.

The hydrocyanic acid content of all the oils distilled and examined in the laboratory falls within the limits prescribed except the oil from prune kernels, which is 0.25 per cent below the lower limit, and the oil distilled from bitter almonds, which is 0.8 per cent above the higher limit.

The oil from apricot kernels (No. 3) is the only oil which reaches the requirement for benzaldehyde, showing by assay 88 per cent, the oil being assayed immediately after distillation. All the remaining oils, including genuine bitter-almond oil and oil purchased on the market, fall below the requirement for benzaldehyde content by several points, the prune and peach oils coming nearest to the requirement.

The prevalent low percentages of benzaldehyde may be accounted for by considering the susceptibility to oxidation which benzaldehyde possesses. Unless oils containing this constituent are kept in vessels that are completely filled and tightly stoppered, and are well protected from the light, oxidation of the benzaldehyde takes place very rapidly, benzoic acid being formed. Decomposition is also facilitated by the presence of water in the oil.[a] Oil free from water is said to possess better keeping qualities. Alcohol[b] also aids preservation if about 10 per cent is added to the oils. As much as 20.7 per cent of benzoic acid is said to have been formed in twelve hours. Samples of the oil have even been known to become a solid mass of crystals[c] (benzoic acid) in a few months.

Admitting this noticeable ease of oxidation, it is not surprising that the benzaldehyde content of the majority of oils examined was low. As all (with the exception of No. 2) were examined almost immediately after distillation, the low and variable content of benzaldehyde may be attributed to the fact that only small quantities of oils were dealt with and the numerous cohobations promoted ease and rapidity of oxidation by exposure of the oil to the oxygen of the air. Sample No. 2, possessing the lowest percentage of benzaldehyde, was kept in a

[a] Tilden, W. A. Hager's Centralhalle, p. 49. 1869.
[b] Proc. Amer. Pharm. Assoc., vol. 43, p. 1027. 1895.
[c] Lücker, Ed. Apoth. Ztg., vol. 20, p. 1044. 1905.

bottle not completely filled, which stood for a period of six weeks before assay.

Nothing is known of the precautions against deterioration taken in the case of sample No. 6, an oil purchased on the market, the low benzaldehyde content unquestionably indicating poor preservation.

A careful survey of the physical and chemical examination of these oils only serves to confirm the statements made that the oils from the several kernels are practically identical in composition, no discriminating characteristics being revealed.

COMMERCIAL USES AND VALUE.

Aside from the medicinal uses of the oil of bitter almonds and other kernel oils, which are valued chiefly for their sedative action produced by the hydrocyanic acid, they find a very extensive application in the perfume industry and for confectioners' purposes. In the latter instance an oil free from hydrocyanic acid must be used. Possibly the greatest part of the oil on the market at present does not enter pharmaceutical channels but is consumed by the confectioner and perfumery maker.

Although the so-called synthetic bitter-almond oil, or benzaldehyde, has done much to reduce the use and to disparage the value of this oil, there still remains considerable demand, both domestic and foreign, for the genuine article, which possesses certain points of value which the synthetic compound does not furnish.

The total importation of bitter-almond oil, or oil purchased under this name, during the year ended June 30, 1906, was 13,487 pounds.[a] The current wholesale price of the oil is from $3.25 to $4.75 per pound,[b] the prices fluctuating with the supply and demand.

Since the manufacture of the oil of bitter almonds from bitter almonds is now carried on only to a limited extent in foreign countries and the imported oil is in a great measure represented by oils made from peach, apricot, and prune kernels, attention may well be directed toward the vast amount of raw materials in the United States from which the oil can be produced.

QUANTITY AND DISPOSAL OF KERNELS.

APRICOT KERNELS.

The commercial production of apricots in the United States is confined chiefly to the State of California. It is estimated by growers that in a normal year there are grown and marketed sufficient apricots to produce as a by-product during the canning and drying operations about 5,000 tons of pits. The ratio by calculation which the kernel

[a] Commerce and Navigation of the United States, p. 988, 1906.

[b] Oil, Paint, and Drug Reporter, vol. 73, No. 5, p. 32.

bears to the pit in the case of apricots is about 20 to 25 per cent. This would mean the production of about 1,000 to 1,250 tons of apricot kernels during a single year.

At the present time the apricot pits are cracked by machinery at an expense of about 1½ cents a pound. The kernels are largely exported to Europe, and especially to Germany, where they are used for various purposes, principally, however, according to reports noted, for the manufacture of the fixed and volatile oils. Only a portion of the yearly output of kernels from California is consumed in the United States, and that probably only for confectioners' purposes.

From the figures presented it is estimated that there is a possible production of from 400 to 500 tons of fixed oil (by expression with hydraulic presses from 350 to 400 tons). From the press cake thus obtained, assuming a yield of 1.5 per cent of volatile oil (which is considerably below the actual yield), about 18,000 to 22,000 pounds of volatile oil could be distilled.

The majority of the kernels produced are exported, with a range of prices during the past six or eight years of from 5 to 12 cents per pound (varying with the crops), and subsequently, to a great extent, imported again by the United States in the form of the volatile and fixed oils produced therefrom.

PEACH KERNELS.

Peaches are produced much more generally in the United States than apricots, although in the California fruit regions much larger quantities of the stones are accumulated at canneries and drying grounds than elsewhere. A rough estimate of the quantity of peach pits obtained as a by-product from the peach industry in California alone during a normal year is 10,000 tons. The ratio of the kernel to the pit in this instance is much less than in the case of apricots, probably varying from 6 to 12 per cent; the California crop should therefore net from 600 to 1,200 tons of peach kernels a year.

The amount of fixed oil obtainable from these kernels by expression is approximately 210 to 420 tons. The amount of volatile oil from the press cake, calculated from a yield of 1 per cent, would be from about 7,800 to 15,600 pounds.

At the present time peach pits are not cracked nor the kernels exported to any great extent. Allowing a small quantity for use by nurseries, the remainder is chiefly used as a fuel, commanding from $5 to $7 a ton for this purpose. A more economical disposal of these kernels, so rich in fixed and volatile oils, might well be made in the United States by the growers and producers.

PRUNE KERNELS.

The pitting of prunes is not carried on to such an extent as is the case with peaches and apricots, this treatment being a relatively new feature. For this reason no figures are available. Attention is nevertheless directed to the large amounts of fixed oil and volatile oil which may be produced from these kernels, as well as from those of apricots and peaches, should they be utilized for this purpose.

SUMMARY.

(1) From the standpoint of relative composition, both the fixed and the volatile oils which can be produced from kernels of peaches, apricots, and prunes compare very favorably, and in some cases are almost identical, with the oils on the market obtained from the kernels of sweet and bitter almonds. The physical and chemical properties correspond in a striking degree to those of the almond oils and point to an extremely close relationship.

(2) In view of the fact that the oils from peach, apricot, and prune kernels are at the present time substituted for the rarer almond oils and have largely replaced them, the production of these oils in the United States suggests itself. Large quantities of kernels, especially of the apricot, are exported annually from the United States at low prices to foreign countries and the products manufactured from them are returned to this country. Peach stones containing kernels are largely burned as fuel. The possibility of a domestic production of these articles of commerce is therefore strongly emphasized by the ready availability of the raw materials.

(3) The adulteration or synthetic production of almond oils is not necessary and should be discouraged. The fixed oils from peach, apricot, and prune kernels can be and are used for the same purposes as almond oils; and such use ought not to be unjustifiable when their similarity of composition is considered. The volatile oils of these fruit kernels are practically identical with the oil of bitter almonds and could therefore entirely replace that oil in commerce, the cheapness of the kernels as compared with bitter almonds making them a more desirable and economical raw material.

(4) The extent of production, taking into account the cheapness and abundance of the raw material, might sufficiently reduce the prices of the fixed oils to render possible a broader and more extensive use than they enjoy at present. Owing to the ready saponification of these oils, a demand in the toilet-soap industry should be forthcoming. Foreign manufacturers are unable at times to supply the demand for almond oil, depending to a certain extent on the supply of the raw material—peach and apricot kernels—from America.

(5) The processes of extraction and distillation of fruit-kernel oils are not particularly complex and are such that the expense of maintaining and operating in establishments or canneries which are already equipped with steam or other power would be comparatively small.

(6) Attention may also be called to the value of the press cake or kernels from which the fixed and volatile oils have been extracted. Important economic use might be made of these extracted kernels as stock foods or as fertilizers, owing to their high content of nitrogenous matter.

(7) Careful consideration by the fruit growers of the United States should be given to peach, apricot, and prune kernels as waste products, with a view to their utilization in the production of important commercial articles heretofore almost entirely imported and representing no small economic value.

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